Marks

- Calculate the standard free-energy change for the following reaction at 298 K. **2**

$$2Au(s) + 3Ca^{2+}(1.0\ M) \rightarrow 2Au^{3+}(1.0\ M) + 3Ca(s)$$

The reduction half cell reactions and E^0 values are:

$Au^{3+}(aq) + 3e^- \rightarrow Au(s) \quad E^0 = +1.50$ V
$Ca^{2+}(aq) + 2e^- \rightarrow Ca(s) \quad E^0 = -2.87$ V

In the reaction, Au is being oxidized and so the overall cell potential is:

$E^0 = ((-2.87) - (+1.50))$ V $= -4.37$ V

The reaction involves 6 electrons so, using $\Delta G^0 = -nFE^0$:

$\Delta G^0 = -(6) \times (96485\ C\ mol^{-1}) \times (-4.37\ V) = +2530000\ J\ mol^{-1}$
$= +2.53 \times 10^3\ kJ\ mol^{-1}$

Answer: **$+2.53 \times 10^3$ kJ mol^{-1}**

Complete and balance the following equation for the reaction between iron(II) ions and permanganate ions in an acidic solution. **2**

$$Fe^{2+} + MnO_4^- \rightarrow Fe^{3+} + Mn^{2+}$$

In acid, the relevant half cells are:

$Fe^{2+}(aq) \rightarrow Fe^{3+}(aq) + e^-$
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$

Giving an overall reaction:

$5Fe^{2+}(aq) + MnO_4^-(aq) + 8H^+(aq) \rightarrow 5Fe^{3+}(aq) + Mn^{2+}(aq) + 4H_2O(l)$

ANSWER CONTINUES ON THE NEXT PAGE

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- What is the value of the equilibrium constant for the following reaction at 298 K?

$$2Fe^{3+}(aq) + Sn(s) \rightleftharpoons Sn^{2+}(aq) + 2Fe^{2+}(aq)$$

The reduction half cell reactions and E^0 values are:

$Fe^{3+}(aq) + e^- \rightarrow Fe^{2+}(aq)$ $E^0 = +0.77$ V
$Sn^{2+}(aq) + 2e^- \rightarrow Sn(s)$ $E^0 = -0.14$ V

In the reaction, Sn is being oxidized and so the overall cell potential is:

$E^0 = ((+0.77) - (-0.14))$ V $= +0.91$ V

The reaction involves 2 electrons so, using $E^0 = \frac{RT}{nF}\ln K$:

$$\ln K = E^0 \times \frac{nF}{RT} = (+0.91 \text{ V}) \times \left(\frac{2 \times 96485 \text{ C mol}^{-1}}{8.314 \text{ J K}^{-1} \text{ mol}^{-1} \times 298 \text{ K}} \right) = 70.9$$

$K = e^{70.9} = 6.05 \times 10^{30}$

Answer: **6.05×10^{30}**